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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Inventors: HEINZ HELBING and PETER STEFFENS.

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COMPLETE SPECIFICATION

Improvements in or relating to Compression-Condensation Refrigeration Systems

We, LINDE AKTIENGESELLSCHAFT, a German Company of Hildastrasse 2-10, 62 Wiesbaden, Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to compression-condensation refrigeration systems having a plurality of compressor cylinders arranged to compress a gaseous refrigerant operating in a closed cycle. The compressor cylinders may be present as one or more multi-cylinder compressors or as a plurality of single-cylinder compressors.

Control arrangements for controlling the refrigerating performance of such a refrigerating system in accordance with the deviation of the temperature of a medium which is to be cooled from a predetermined value to correct such deviation are already known in which an automatic temperature-operated valve is located in the suction line, by means of which the refrigerating performance can be varied over a range corresponding to a single compressor stage and in which, when the operation of the valve is insufficient to correct the deviation, a suction pressure control switch switches a compressor stage in or out as required at predetermined time intervals until the deviation has been corrected. The compressor stages in this case are constituted, in the case of a single compressor, by, for example, a group of cylinders, or, in the case of a plurality of compressors, by an individual compressor.

It is also known to arrange a temperature-controlled valve in a by-pass line between the pressure and suction sides of a compressor and to make the compressor operate in dependence on time by the use of limit switches incorporated in the valve.

[Price 4s. 6d.]

It is also known, in the case of a plant employing several compressors and using a controller which is influenced by temperature or by pressure, only to switch individual compressors in and out in stages in accordance with refrigerating requirements, without using an automatic control valve as in the known arrangement referred to above.

The use of such known control devices, however, entails a relatively high power consumption. Moreover, it is only possible to achieve high accuracy in control when using control devices of this kind at heavy expense.

It is an object of the invention to provide a compression-condensation refrigeration system including a control arrangement for controlling the refrigeration performance of the system, the operation of which control arrangement entails as little waste as possible. It is a further object to provide a refrigeration system having a control device by use of which a high degree of accuracy in control can be obtained at small expense.

According to the invention, there is provided a compression-condensation refrigeration system having a plurality of compressor cylinders arranged to compress a gaseous refrigerant operating in a closed cycle and including a control arrangement comprising a motor-operated control valve arranged in a by-pass line connecting the high and low pressure sides of the system and means for operating said control valve in accordance with the deviation of the temperature of a medium being cooled by said system from a predetermined temperature or temperature range to correct said deviation, wherein said control valve when fully open has a free-flow cross-sectional area which will permit the passage of such a quantity of refrigerant as corresponds to

the maximum refrigeration capacity of one compressor cylinder, and wherein said control valve is provided with limit switches adapted to be operated when said control valve is either fully open or fully closed to switch out or switch in a compressor cylinder respectively and to return the control valve to the other limiting position.

The limit switch of the control valve corresponding to the fully open position of the valve and therefore to the free-flow cross-sectional area of the valve at this position is conveniently adjustable as a function of the predetermined temperature or temperature range, so that the free-flow cross-sectional area can be arranged to correspond to the refrigeration capacity of one compressor cylinder even when the predetermined temperature or temperature range to which the medium is to be cooled, is selected over a wide range of possible values. The motor operated control valve can preferably be adjusted between its fully closed and fully open positions in dependence upon the magnitude of the deviation of the temperature being cooled from the predetermined temperature or temperature range.

In accordance with a preferred form of the invention, the motor-operated control valve is connected with a temperature sensor adapted to measure the temperature of the medium being cooled via a stepwise control device. The intervals between steps and the duration of each step may be automatically adjustable in dependence upon the extent of the deviation of the temperature of the medium being cooled from the predetermined value.

The largest open cross-sectional area of the motor-operated control valve is determined by the maximum refrigerating performance of a compressor cylinder for the particular temperature range required. In this way, by by-passing gaseous refrigerant through the valve open to its maximum free cross-sectional area, the refrigerating performance of a particular compressor cylinder can be reduced to the maximum extent.

The stepwise control device and the motor-operated control valve are so designed that the free flow cross-section of the motor-operated control valve decreases with increasing refrigeration requirement and increases with reducing requirement, assuming the same number of compressor cylinders to be in operation.

At the two end positions of the motor-operated control valve, i.e. the valve being entirely shut or entirely open, limit-switches are arranged which switch in or out the compressors via a time-delay switch. If the motor-operated control valve has in stepwise manner reached one of its end positions, then a compressor is either switched in or switched out and the motor-operated control valve returns uninterruptly to its other end position.

The control arrangement of the present invention possesses substantial advantages over known control devices. For instance, it is more economical in operation, due to the saving in the current taken by the compressor motor or motors when a compressor cylinder is switched out. Moreover, with the control arrangement of the present invention, a higher degree of accuracy in control can be attained for less expense, i.e. the installation costs are less.

The invention will be further described with reference to the accompanying drawing, which is a diagrammatic flow sheet of a refrigerating plant according to the invention, by means of which plant the temperature in a refrigerated space 1 is to be maintained within a predetermined temperature range constituted by limits of 0.5°C. about a predetermined temperature over a wide range of possible predetermined temperatures, depending upon the different articles to be cooled therein. From an evaporator 2, compressors 3, 4 and 5 draw refrigerant vapour through a suction line 6 and force it through a pressure line 7 into a condenser 8. The refrigerant liquefied in the condenser then flows into a collector 9 and thence, through an adjustable expansion valve 10, back to the evaporator 2.

Between the pressure line 7 and the evaporator 2, there is a by-pass line 11 which contains a motor-operated control valve 12. If the control valve 12 is open, then vaporous refrigerant can flow directly to the evaporator 2. The largest free cross-sectional area of the control valve 12 is so adjusted that the quantity of vapour flowing through corresponds to the refrigeration capacity of one of the running compressors in the particular temperature range concerned. The free cross-sectional area of the valve 12 when fully open is adjustable in accordance with the particular value of the pretermined temperature, so that it can be arranged to correspond to the refrigeration capacity of a compressor for a wide range of such predetermined temperatures. Consequently, with this valve in the fully open position in each case a compressor will effectively be cut out, i.e. if, for example, two compressors are running, the actual refrigerating performance will correspond to that attainable with one only.

Regulation of the control valve 12 is effected in stepwise fashion by a stepwise control device 13 in accordance with the readings of a temperature sensor 14. The intervals between steps and the duration of a step of the control device 13 are automatically adjustable in accordance with the degree of deviation of the temperature of the

room 1 from the predetermined value. Correction of a deviation of this temperature from the predetermined value takes place in the following manner:

If the temperature in the refrigerated space 1 rises, e.g. exceeds the predetermined value by more than 0.5°C., then control commences. The control valve 12 runs briefly in the "closed" direction. The quantity of refrigerant flowing through the by-pass line 11 is thus reduced and the quantity flowing through the condenser consequently rises bringing about an increase in the refrigerating performance of the operating compressors. There follows a pause, in which it is established what result the adjustment of the control valve 12 has had. If the deviation from the predetermined value persists in the same direction after a specific sampling time, the brief adjustment of the control valve 12 in the "closed" direction is again initiated.

However, if despite this periodic brief adjustment of the control valve 12, the temperature of the refrigerated space 1 has risen still further and if a specific value (greater than 0.5°C. above the predetermined temperature) is exceeded, then the automatic system switches to periodic long-time operation of the motor control valve 12. The mode of operation for this is basically the same as with the short-time operation except that the times of operation of the control valve 12 are longer so that the alteration of the free-flow cross-sectional area of the valve is greater for each operation and the temperature deviation is more effectively countered.

If the air temperature in the space 1 exceeds a predetermined somewhat higher value, then the operation of the control valve 12 in the "closed" direction is no longer a stepwise process, but becomes continuous.

If the control valve 12 reaches the "closed" end position (i.e. is fully closed), then a limit-switch 15 activated by the stepwise operation of the control device to close the valve arranged to operate when the valve 12 is in this position, is operated to switch in a further compressor through a starter 16.

At this moment, the control valve 12 returns uninterruptedly to the other end position (i.e. where it is fully open) so that initially the additional compressor which has been switched in is not effective. The rapid uninterrupted movement of the control valve to the other end position at which it is fully open does not activate the limit switch 15 at this position, so that this switch does not operate to switch out a compressor. In this way, the transition from one compressor to the next is effected in a smooth manner.

If, however, the temperature in the refrigerated space 1 drops by 0.5°C. below the predetermined value, then the control valve 12 runs briefly in the "open" direction. If required, there may again be a change from short-time to long-time adjustment. If, owing to a decreasing refrigerating requirement, the motor control valve 12 reaches the "open" end position (i.e. is fully open), then the limit-switch 15 incorporated at this position operates and a compressor is switched out via the starter 16. At the same time, the control valve 12 returns to the other end position (i.e. to the fully closed position), so that the compressor or compressors left running is or are fully effective. As before, the rapid uninterrupted return of the control valve 12 to the other end position does not activate the limit switch at this position, so that a compressor is not switched in. The refrigerating performance can thus be regulated on the one hand within the range of a single compressor by virtue of the control afforded by the motor-operated control valve 12, and on the other hand, by the switching in or out of further compressors, affording together a very wide range of continuous control.

The control arrangement of the present invention may, moreover, be so arranged that the end of a pause, e.g. a pause elapsing after a short-time adjustment, is not waited for if the temperature of the refrigerated space falls below or exceeds the value predetermined for commencement of long-time adjustment during the actual time of the pause itself, that is to say, a new adjustment is immediately commenced.

Equally, it may also be arranged that the complete pause is not allowed to elapse if, on the occurrence of a fluctuation in the temperature of the space 1 about the predetermined value, the curve tracing such fluctuation intersects the line of the predetermined value. In such a case, short-time adjustment of the control valve 12 will be initiated and the operation of this valve will in all cases be such that the incipient deviation from the predetermined value is counteracted. Such fluctuation of the temperature of the refrigerated space about the predetermined value generally arises after a sudden disturbance of the steady state condition.

Since, with a control arrangement of the kind in question, a continuous control is possible together with high control accuracy, all for a relatively small outlay, such a control arrangement may advantageously be employed in circumstances where the maximum temperature accuracy is desired and where high-sensitivity sensors are used, i.e. in chemical systems and low-temperature cooling systems for vulnerable refrigerated articles.

WHAT WE CLAIM IS:—

1. A compression-condensation refrigerating system having a plurality of

compressor cylinders arranged to compress a gaseous refrigerant operating in a closed cycle and including a control arrangement comprising a motor-operated control valve arranged in a by-pass line connecting the high and low pressure sides of the system and means for operating said control valve in accordance with the deviation of the temperature of a medium being cooled by said system from a predetermined temperature or temperature range to correct said deviation, wherein said control valve when fully open has a free-flow cross-sectional area which will permit the passage of such a quantity of refrigerant as corresponds to the maximum refrigeration capacity of one compressor cylinder, and wherein said control valve is provided with limit switches adapted to be operated when said control valve is either fully open or fully closed to switch out or switch in a compressor cylinder respectively and to return the control valve to the other limiting position.

2. A refrigerating system as claimed in Claim 1 wherein the limit switch of said control valve corresponding to the fully open position of said valve and therefore to the free-flow cross-sectional area of the value in this position, is adjustable as a function of said predetermined temperature or temperature range.

3. A refrigerating system as claimed in Claim 1 or Claim 2 wherein said motor-operated control valve is adjustable between its fully open and fully closed positions in dependence upon the magnitude of the deviation of the temperature of said medium from said predetermined temperature or temperature range.

4. A refrigerating system as claimed in Claim 3 wherein said means for operating said control valve comprise a temperature sensor adapted to measure the temperature of the medium being cooled and connected to said control valve through a stepwise control device.

5. A refrigerating system as claimed in Claim 4 wherein the intervals between steps and the duration of each step of said stepwise control device are automatically adjustable in dependence upon the extent of the deviation of the temperature of the medium being cooled from said predetermined temperature or temperature range.

6. A refrigerating system for controlling the refrigerating performance of a refrigerating plant in accordance with the deviation of the temperature of a medium being cooled from a predetermined value to correct such deviation, substantially as hereinbefore described with reference to the accompanying drawing.

For the Applicants,
G. F. REDFERN & CO.,
St. Martin's House, 177 Preston Road,
Brighton, BN1 6BB.
Chansitor House, 38 Chancery Lane,
London, W.C.2.

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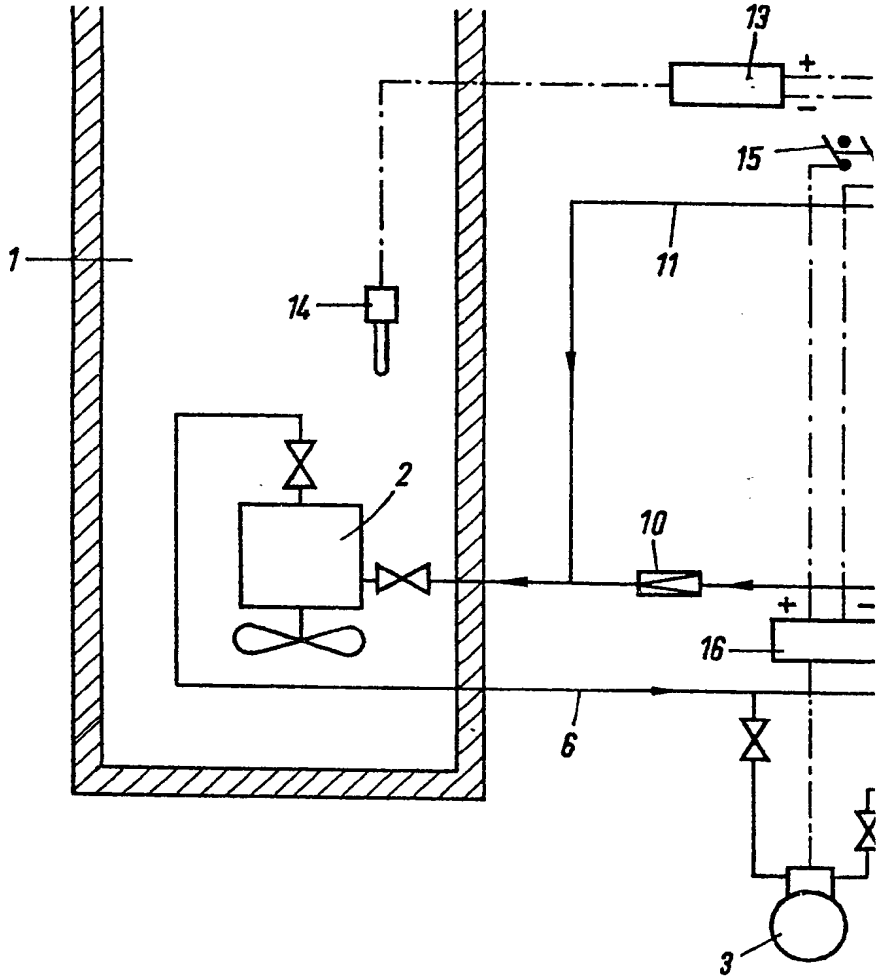

1,139,734 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.